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S I R:

I, Charles Bullock, declare and state that I am knowledgeable in German and English, and I hereby certify that the attached translation of the attached German Priority Application 10 2004 010 005.5, filed in the German Patent and Trademark Office on 1 March 2004, is truthful and accurate to the best of my knowledge.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Title:	System for image-assisted shock wave treatment
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The attached pieces are a correct and exact reproduction of original documents of this Patent Application

Munich, the 11th of November 2004
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Klostermeyer

Specification

INSTALLATION USED FOR IMAGE-ASSISTED SHOCK WAVE THERAPY

The invention concerns a system for image-supported shock wave treatment. The main components of such a system are a therapy system and an x-ray system. The therapy system comprises a shock wave head that generates ultrasonic waves directed towards a focus point. The disintegration of kidney and ureter stones is primarily considered as a therapy purpose. However, other applications for treatment of Peyronie's disease or in the field of pain therapy and gastroenterology are also conceivable. The x-ray system serves for location of the stone in the treatment area of a patient and for observation of the treatment success accompanying therapy. It comprises an x-ray source and an x-ray receiver or, respectively, image intensifier. Both devices are fixed on the blade ends of a c-shaped arc (called an x-ray C-arm in the following) that can move orbitally around its isocenter. In the application case the x-ray C-arm partially encompasses a patient table or, respectively, is partially crossed by this in the direction of an axis running at a right angle to the orbital plane of said x-ray C-arm.

Given the treatment of a patient with a system of the type illustrated above, the focus point of the shock wave head must be aligned on the isocenter of the x-ray C-arm or, respectively, coincide with this so that, given an orbital or angular movement of the x-ray system required for 3D positioning, the beam axis of said x-ray system always runs through the focus point or, respectively, through a volume region comprising this focus point. In the application case, the therapy subject to be treated must correspondingly likewise be arranged in the cited region, meaning that the patient must be positioned in a suitable position on the patient table. Given systems with stationary shock wave head, this requirement can only be satisfied by a position that is uncomfortable for the patient, for example via a prone position that is in particular critical given adipose patients.

In a system known from DE 298 24 080 U1, a carrier device (fashioned as a C-arm) for a shock wave head is arranged in the orbital plane of an x-ray C-arm that can exclusively be angularly panned. The C-arm comprises a first arc segment fixed on the x-ray C-arm and a second arc segment borne on the first fixed arc segment such that it can shift on this segment, which second arc segment bears the shock wave head on its free end. The first arc segment and the x-ray C-arm itself can be panned around a common horizontal axis (thus angularly) running in the orbital plane and through the isocenter of the x-ray C-arm. Due to this embodiment, a shock wave head can be positioned both above and below a patient table. However, it is disadvantageous that the space circumscribed by the x-ray C-arm is crowded by the carrier device present therein such that a displacement of the patient table running horizontal and parallel to the orbital plane is barely still possible. Given a change from a left-side treatment position to a right-side treatment position, the respective patient volume can therefore not be brought into the focus point or, respectively, the isocenter via a table displacement given an unchanged patient position. Rather, a head-to-foot rearrangement of the patient is necessary. The result is that the previous spatial installation of the new patient table be adapted to the new patient position; for example, a time-consuming reconstruction of auxiliary devices (such as anesthesia devices) must be conducted.

It is the object of the invention to suggest a system for shock wave treatment that is improved in this regard.

This object is achieved via a system according to claim 1. This comprises an x-ray C-arm that can move orbitally around an isocenter and a carrier device for the shock wave head that is arranged stationary and axially offset relative to said x-ray C-arm. A boom extending up to the x-ray C-arm is connected with the carrier device with its fixed end and bears the shock wave head with its free end. With the help of the carrier device the boom is directed in a movable manner such that the shock wave head can be arbitrarily positioned in the orbital plane within an angle

range of at least 180° above and below a patient table and can be aligned on the isocenter. Via the axially-offset arrangement of the carrier device, the entire space enclosed by the x-ray C-arm is freely accessible. This allows a patient table to be horizontally displaced insofar as that a treatment change from the right patient side to the left patient side (thus a positioning of the left-side or right-side treatment area of the patient in the isocenter) can ensue without having to effect a head-to-foot rearrangement. The original setup of the system can thereby be retained, which is in particular advantageous when, for instance, a patient with kidney stones on both sides is treated. Due to the movement capability of the boom (and with it of the shock wave head) in an angle range of at least 180°, the latter can, for example, be arranged in an under-table position with vertical alignment of its shock wave axis (0° position) and in an over-table position with the same alignment of the shock wave axes (180° position). Given a panning range of 230°, a panning from the vertical over-table position (180°) up to a panned-through -50° position under the table can ensue. Nearly all treatment situations on a patient can hereby be implemented in one and the same patient position. In the extreme case, the carrier device can be designed such that an angle range of 360° can be covered with the shock wave head. A large variability is thus available with regard to the selection of the treatment position of the shock wave head; for example, a ureter stone treatment can be effected from an over-table or under-table position given a dorsal position of the patient.

If the carrier device for the shock wave head is arranged in the head direction of the patient with regard to the x-ray C-arm, the doctor has free access to the patient up to the height of the point of the patient to be treated and also from the foot region of the patient on the side facing towards the machine such that, for instance, a trans-urethral procedure is possible without hindrance. In spite of the cited arrangement, sufficient freedom of movement is still present for an anesthesiologist operating in the head region of the patient.

Due to the orbital movement capability of the x-ray C-arm, both the locating and the observation during the treatment (perhaps the progress of a stone disintegration) can ensue from the direction of the shock wave axis, which offers a higher targeted precision (inline positioning). A shadowing of the x-ray by a carrier structure for the shock wave head that is arranged within the x-ray C-arm is thereby not to be feared. Only the shock wave head itself is arranged within the volume range swept over by the x-ray of the x-ray system. The boom bearing said shock wave head thereby does not interfere, in particular when this grasps the shock wave head from the side with its free end. In summary, according to the invention a system is thus provided that allows a shock wave treatment in arbitrary angle positions as well as from different intromission angles given an always-constant alignment and dorsal position of the patient, as well as the precisely-targeted x-ray inline positioning and a nearly hindrance-free observation with the aid of the x-ray system during the treatment. The system is therefore likewise suitable for a plurality of applications, for example IPP, kidney, ureter and bladder stones, trans-urethral procedures.

In that both sub-systems (namely the x-ray system and the therapy system) are stationary relative to one another, for example accommodated on a common base body, their position relative to one another is mechanically fixed. For instance, given the mounting of the system an adjustment can thus ensue to the effect that the focus point of the shock wave head is directed on the isocenter or, respectively, coincides with this in every treatment position. For instance, the usage of an electronic positioning system for position establishment or, respectively, calculation of the position of focus and isocenter is therefore not necessary.

In a preferred embodiment it is provided that the boom is forcibly directed in a plane parallel to the orbital plane of the x-ray C-arm. A lateral evasion of the focus point of the shock wave head from the orbital plane of the x-ray C-arm is thereby prevented.

In a first preferred embodiment, the carrier device is a C-arm (designated in the following as a therapy arc) arranged axially offset and coaxial relative to the x-ray C-arm, on which C-arm the boom is borne with its fixed end such that said boom can move orbitally. This embodiment allows a completely guided movement of the shock wave head in the orbital plane of the x-ray C-arm. An adjustment of the focus point of the shock wave head on the isocenter of the x-ray C-arm, which adjustment is effected given the new installation of a system, is retained.

In the normal case, a movement of the shock wave head around a specific angle range requires a therapy arc with at least correspondingly-dimensioned arc length. Given a movement capability of the shock wave head, for example by 250°, a correspondingly-dimensioned therapy arm would widely overlap a treatment table on the top and bottom and thereby limit the movement freedom of a treating doctor on the treatment side of the patient table. In order to prevent this, a preferred system variant possesses a therapy arc that is borne such that it can be orbitally displaced. The therapy arc can now be significantly shortened since the maximum travel path of the shock wave head results from the travel length of the therapy arc on the one hand and the travel length of the shock wave head on the therapy arc on the other hand. To shorten the therapy arc length it is also conceivable that this is formed from two arc segments that can be orbitally displaced against one another. Another possibility for arc truncation is to affix the boom on the therapy arc such that said boom can rotate, such that its free end can be pivoted into a position protruding over a blade end of the therapy arc.

In a second embodiment of the system, the carrier device is an articulated arm comprising a plurality of arm segments connected via joints, with the free end of which articulated arm the fixed end of the boom is connected. While an establishment of the movement of the boom or, respectively, of the shock wave head in an orbit is connected with a therapy arc, the desired treatment positions of the shock wave head can be achieved given use of an articulated arm as a carrier device with arbitrary movement paths, wherein a control device for isocentric

alignment of the shock wave head is then required. In an advantageous embodiment the degree of freedom of the articulated arm is limited such that it can move only within a plane parallel to the orbital plane of the x-ray C-arm. This is achieved appropriate manner in that the joints of the articulated arm connecting the arm segments exhibit rotation axes running parallel to one another and at right angles to the orbital plane of the x-ray C-arm, thus are all fashioned as hinge joints. In order to be able to isocentrically align the shock wave head in each angle position, the boom is rotatably connected with the free end of the articulated arm.

In both embodiments, a shock wave head is provided that is crossed by a central region that is permeable to x-rays and extends along the shock wave axis of said shock wave head. This embodiment allows a precisely targeted "inline positioning" with the x-ray system without position change of the shock wave head, thus also during a lithotripsy treatment. In a design that is likewise advantageous for both embodiments, the carrier device (together with the shock wave head) can be moved from a treatment position into a park position removed from a patient table or, respectively, a patient borne thereupon. The freedom of movement in the space located between x-ray C-arm and head end of the patient table or, respectively, generally in the abdominal region of the patient can thereby be increased.

In order to not hinder an orbital movement of the x-ray C-arm and of the therapy arc or, respectively, a movement of the articulated arm on the underside of the patient table, this is borne at one end, for example at the head end, thus outside of the movement range of the cited devices.

The exemplary embodiments of the drawings are referenced for a further description of the invention. Shown, respectively in a perspective principle representation, are:

Fig. 1 a shock wave lithotripsy system in a first embodiment with shock wave head in the over-table treatment position and x-ray C-arm in base position (inline with the shock wave head),

Fig. 2 the system from Fig. 1 with shock wave head in under-table treatment position for the left (machine-distal) patient side, with x-ray system orbitally panned into inline position,

Fig. 3 the system from Fig. 1 with therapy C-arm and shock wave head in park position.

Fig. 4 the shock wave lithotripsy system in a second embodiment with articulated arm and shock head in park position and x-ray C-arm in base position,

Fig. 5 the SWL system from Fig. 4 with parked (thus swiveled-out) x-ray C-arm and shock head in treatment position (under-table – right),

Fig. 6 the system from Fig. 4 with shock head in treatment position (under-table – left) and tilted x-ray C-arm in inline position.

Fig. 1 shows an SWL system 2 in a first embodiment that comprises the following sub-components: an x-ray C-arm 4, a therapy C-arm 8 (bearing a shock wave head 6 and characterizing the first embodiment) as a carrier device, a patient table 10 and a display module 12. The x-ray C-arm 4 comprises a two-part base body 14 on which a C-arm segment 16 is borne such that it can move. A circle segment-shaped support 18 (not visible) is present in the base body 14 for this, in which support 18 the C-arm segment 16 is forcibly guided, optimally without play. The C-arm segment 16 can therefore be moved one-dimensionally in the orbital direction indicated by the double arrow 20.

The two-part base body 14 comprises a base 24 that is stationary at rest. A guide 28 that can rotate around a pivot axis 26 running horizontally is attached on this base 24 via a swivel joint 34. The pivot axis 26 intersects a longitudinal axis 22 at an isocenter 32. The x-ray C-arm 4 can be panned angularly around the pivot axis 26. The orbital panning movement of the C-arm segment 16 ensues around a longitudinal axis 22 running horizontally given the angular base position shown in Fig. 1. Given angular panning of the x-ray C-arm 4, its orbital panning then ensues around a rotation axis (not shown) tilted corresponding to the longitudinal axis 22.

An x-ray source 34 and an image intensifier 36 are mounted on the two ends of the C-arm segment 16. The x-ray source 34 and the image intensifier 36 together form an imaging system whose center ray 38 likewise runs through the isocenter 32. It is thus ensured that the center ray 38 pierces the isocenter 32 in every angular and orbital position of the C-arm segment 16.

The C-arm segment 16 is shown in its base position in Fig. 1, meaning that the center ray 38 runs in the perpendicular direction. Via orbital movement of the C-arm segment 16 in direction 20 (as, for example, shown in Fig. 2), the center ray 38 traveling as well [sic] spans an orbital plane 40 which contains the center ray 38 and the pivot axis 26. For reasons of clarity, the orbital plane 40 in Fig. 1 is only shown hatched in a very small region; however, it also extends beyond the hatched region and the diameter of the x-ray C-arm 4.

On its side 42 situated radially outwards, the therapy C-arm 8 is borne on a guide 44. A support 46 (not visible) corresponding to the support 18 is present in the guide 44 for this, on which support 46 the therapy C-arm 8 can move orbitally in the direction of the arrow 48. With its end 50, the guide is borne on the bearing block 52 of a base body 54. A non-visible joint 56 is hereby arranged between bearing block 52 and guide 44, which allows a rotation around an axis 58 parallel to the longitudinal axis 22.

As an alternative or in addition to the shown embodiment, guide rails (not shown in Figures) with corresponding sleds can also be attached on the base body 54 or, respectively, bearing block 52 and on the guide 44, on which guide rails the therapy C-arm 8 can be shifted away from the patient region together with the guide 44, for example parallel to the axis 26. Other arrangements of rails are also conceivable, such that the x-ray C-arm 4 together with the shock wave head 6 can move two-dimensionally along said sled within certain limits.

A sled 62 is borne on the radially-inwards side 60 of the therapy C-arm 8 such that said sled 62 can likewise move orbitally in direction 48. A boom 64 is attached on the sled 62 with its fixed end 67, which boom 64 points in the direction towards the x-ray C-arm 4 and bears the shock wave head 6 on its free end 66. For orbital movement of the shock head 6, sled 62 on the therapy C-arm 8 and therapy C-arm 8 on the guide 44 are simultaneously moved, for example via a chain drive (not visible in Fig. 1) arranged inside the therapy C-arm 8. That the two movements just cited are thereby no longer independent of one another is irrelevant for the functionality of the system 2. The orbital movements of therapy C-arm 8 and sled 62 likewise ensue around the longitudinal axis 22.

The entire therapy C-arm 8 with its base body 54 is displaced at an axial separation from the x-ray C-arm 4 or, respectively, parallel to the orbital plane 40, meaning that the plane that the therapy C-arm 8 spans lies parallel to the orbital plane 40 and separated from this. The boom 64 extends in the direction towards the x-ray C-arm 5 so far that the shock wave head 6 attached on it in turn lies in the orbital plane 40. The distance is measured such that a focus point 70 of an ultrasonic shock wave emitted by the shock wave head 6 and represented in Fig. 1 by the cone 72 lies in the orbital plane 40, whereby the cone tip forms the focus point 70 and lies in the isocenter 32. The shock wave head 6 is an ultrasound shock wave head for generation of an ultrasonic pulse focused in the focus point 70.

The shock axis 68, thus the propagation direction of the ultrasonic pulse, hereby passes through the focus point 70, lies in the orbital plane 40 and coincides with the center ray 38 in Fig. 1. For this reason one speaks in Fig. 1 of what is known as an inline position of shock wave head 6 and x-ray system 34, 36. Due to an x-ray-transparent zone 96 (visible in Fig. 2) surrounding the shock axis 68 in the shock wave head 6, during the shock wave treatment of a patient 76 a simultaneous x-ray positioning of the subject to be treated or, respectively, an exposure of the surroundings of the focus point 70 inside the patient body can in fact occur. The x-rays emitted from the x-ray source 34 can penetrate the x-ray-transparent zone 96 of the shock wave head 6 along the center ray 38. At the same time the shock wave head 6 is positioned on the stomach-side of the patient in order, for example, to treat a stone in the ureter of the patient. Here one speaks of what is known as the over-table treatment position.

Due to the coaxial arrangement of x-ray C-arm 4 and therapy arc 8, the position of the focus point 70 is maintained in the isocenter 32 in every travel position of the shock wave head 6. The shock axis 68 always lies in the orbital plane 40.

The exact geometric alignment of articulated arm 8 and x-ray C-arm 4 relative to one another ensues in that the base body 14 and the base body 54 are mounted on common foot part 74. The alignment is hereby effected at the factory in the manufacture of the SWL system 2.

The treatment point of the SWL system 2 in which the focus point 70 is to be lazed always lies in the isocenter 32. In an imaging phase of the treatment of the patient 76 he, with his point to be treated, is therefore brought into the isocenter 32 (already occurred in Fig. 1). In order to non-invasively locate the point to be treated inside the patient 76, the imaging system (consisting of x-ray source 34 and image intensifier 36) supplies x-ray exposures which are shown on screens 82 of the display module 12. Via the flexible, weight-compensating carrier arm 84, the screen 82 can be moved into an advantageous observation position for the operator

of the system 2. In order to three-dimensionally position the treatment point, at least two x-ray images of the patient 76 are created (possibly given a shock wave head 6 that is initially pivoted away) in that the x-ray C-arm 4 is panned around the axis 22 (orbital positioning) or 26 (angular positioning), for example between the positions shown in Fig. 1 and Fig. 2. For movement of the patient 76, a recumbent surface 78 on which the patient 76 rests is borne at the head on a permanently-installed base 80 and can be moved linearly in all spatial directions 90.

The approach of the shock wave head 6 towards the patient 76 can ensue in two ways. Either the treatment position of the patient 76 is sought first and then marked, for example electronically stored given a recumbent surface that can be moved via motors. The recumbent surface 78 together with the patient 76 is subsequently moved a bit so that the shock wave head 6 can be moved into the position shown in Fig. 1; the patient 76 is then moved towards the shock wave head 8 [sic] from below until the treatment position stored above is reached again. The position shown in Fig. 1 is thus reached.

Alternatively, due to the entire therapy C-arm 8 that can be panned around the axis 58 the coupling of the shock wave head 6 can also ensue on the patient 76 brought into the treatment position (and henceforth recumbent), in that the therapy C-arm 8 previously pivoted upwards is lowered together with the shock wave head 6 onto the abdomen (facing upwards) of the patient 76. This coupling variant applies in particular for the embodiment of the SWL system 2 according to Fig. 4 through Fig. 6.

If the shock wave head 6 is coupled to the patient 76, the treatment can be begun via activation of the ultrasonic shock waves.

When it is not directly required, the entire x-ray C-arm 4 can be pivoted away from the patient region (not shown in Figures) on a further rotation axis 86 that passes perpendicularly through the base body 14 and the foot part 74, which increases the

access for the treatment personnel at the patient 76. The pivoting ensues from the base position shown in Fig. 1 in the direction of the arrow 88.

An evasion of the shock wave head 6 (conditional upon its dead weight and the contact pressure on the patient and the deformation of the therapy C-arm 8) can, for example, be corrected via a slight panning of the therapy C-arm 8 around the axis 58.

The treatment position shown in Fig. 2 (namely what is known as the under-table left position) treats, for example, the left kidney of the patient 76. The shock wave head 6 is panned into the under-table position. Relative to Fig. 1, the sled 62 (covered in Fig. 2 by the x-ray source 34) is moved to the opposite end of the therapy C-arm 8. The therapy C-arm 8 itself is additionally moved in its guide 44 to the opposite end relative to Fig. 1. The shock wave head 6 protrudes into a recess 92 of the recumbent surface 78 in order to be brought optimally close to direct contact on the patient 76. The cone 72 of the ultrasonic rays generated by the shock wave head 6 hereby penetrates a water-filled coupling bellows (not shown) which is coupled between shock wave head 6 and patient 76 under intermediate layer of gel and furthermore with the body tissue of the patient insofar as that the focus point 70 strikes a kidney stone (not shown) in the body of the patient 76.

As in Fig. 1, the x-ray C-arm is located in base position with regard to the axis 26. However, it is pivoted counterclockwise by approximately 40 degrees in direction 20 in order to expose the patient 76 at an angle. The 40 degree position is a typical position for treatment of kidney stones.

In Fig. 2 it is to be recognized that the shock wave head 6 on the boom 64 is eccentrically mounted, namely on the side of the boom 64 facing away from the system in the under-table position. In the direction of the front side 94 of the recumbent surface, the shock wave head 6 hereby stands further removed from the

patient table 10 than the therapy C-arm 8 and the boom 64. The doctor normally standing next to the patient table 10 on the front side 94 is hereby limited as little as possible in his legroom or, respectively, freedom of movement. Since, in the upper-table position, the 180 degree position of the shock wave head 6 shown in Fig. 1 is the most extreme position of the shock wave head 6, here the projection of therapy C-arm 8 and boom 64 is also bearable for the treating doctor in his head region. A further possibility to make the C-arm smaller is moreover hereby provided.

The central x-ray-transparent zone 96 in the shock wave head 6 is visible in Fig. 2, which x-ray-transparent zone 96 serves for inline positioning in the shock wave treatment. Due to the stationary resting isocenter 32, the recumbent surface 78 is somewhat raised relative to Fig. 1 and displaced towards the right patient side in order to place his left kidney in the treatment point (thus the isocenter 32) instead of his ureter.

Fig. 3 shows the therapy C-arm 8 in park position. The entire therapy C-arm 8, together with the shock wave head 6, is pivoted upwards by approximately 90 degrees around the axis 58 from the position shown in Fig. 1. The entire patient torso region is hereby cleared, which makes the access to the patient 76 distinctly easier for treatment personnel. This is advantageous in an emergency situation or given the treatment preparation or follow-up.

Fig. 4 shows the SWL system 2 in an alternative embodiment, namely with an articulated arm 208 as a carrier device.

The articulated arm 208 is borne with its one end 242 on the bearing block 244 of the base body 54. A joint 248 is hereby arranged between bearing block 244 and an arm segment 250, which joint 248 allows a rotation on an axis 252 parallel to the longitudinal axis 22. A further joint 256 which can be pivoted on an axis 258 likewise running parallel to the longitudinal axis 22 is attached between the arm

segment 250 and a further arm segment 254. A further joint 262 is attached at the free end 260 of the articulated arm 208, which joint 262 connects the arm segment 254 with the boom 64 and which allows rotation (together with the shock head 6) on the axis 266 likewise running parallel to the longitudinal axis 22.

The entire articulated arm 208 with its base body 46 is offset by an axial distance from the x-ray C-arm 4 or, respectively, parallel to the orbital plane 40, meaning that the longitudinal axes of the arm segments 250 and 254 run parallel to the orbital plane 40. The boom 64 extends in the direction of the x-ray C-arm 4 so far that the shock head 6 attached on it in turn lies in the orbital plane 40. The separation is measured such that the focus point 70 of the ultrasonic shock wave (represented in Fig. 4 by the cone 72) emitted by shock head 6 lies in the orbital plane 40. The shock axis 68 again passes through the focus point 70 and lies in the orbital plane 40.

Due to the parallelism of all axes 252, 258 and 266 around which the individual parts of the articulated arm 208 can be pivoted, the focus point 70 can only be displaced two-dimensionally and in fact always within a region of the orbital plane 40 demarcated by the dimensions of the articulated arm 208. The focus point 70 can in particular be directed towards the isocenter 32 via pivoting of the articulated arm 208.

In Fig. 4 the articulated arm 208 and the shock head 6 is [sic] moved into what is known as a park position, i.e. moved as far as possible from the surrounding region of the patient 76 resting on the patient table 10. The access to the patient 76 from all sides is thus possible without hindrance for treatment personnel or, respectively, doctors (not shown). For example, in the situation shown in Fig. 4 an imaging phase can ensue before or after the treatment of the patient 76. The ultrasound cone 72 and the focus point 70 is [sic] in fact shown in Fig. 4; however, the ultrasound source is normally deactivated.

If the body region of the patient 76 to be treated lies in the isocenter 32, the shock head 6 is directed towards the patient by pivoting the articulated arm 208. The patient does not have to be re-moved for this. The x-ray C-arm 2 is hereby to be temporarily tilted on the pivot axis 26 out of its angular base position shown in Fig. 4 in order to avoid a collision. If the focus point 70 is brought into the isocenter 32, the treatment can be begun via activation of the ultrasonic shock wave.

The entire x-ray C-arm 4 can be pivoted out of the patient region on the rotation axis 86 that crosses perpendicular to the base body 14 and the foot part 74, which enables the unlimited access to the patient 76 for the treatment personnel. This park position of the x-ray C-arm 4 is shown in Fig. 5. Instead of this the articulated arm 208 is moved into a treatment position in which the focus point 70 coincides with the isocenter 32. The right kidney can thus be treated from approximately the 40° position at the back of the patient 76; this is what is known as the under-table right position.

Angle sensors (not shown) which detect the respective rotation position of the appertaining joint and forward it to a central computer (not shown) are present in the joints 248, 256 and 262. The respective position of the arm segments 250 and 252 or, respectively, of the shock wave head 6 and thus of the focus point 70 can be determined in a suitable manner in the central computer from the known dimensions of the entire articulated arm 208 via detection of the rotation angle of the joints 248, 256 and 262. This central computer controls the motors (likewise not shown) in the joints 248, 256 and 262 such that the focus point 70 comes to lie exactly in the isocenter 32. An automated control of the entire articulated arm 208 or, respectively, its movement is thus enabled.

Due to the x-ray C-arm 4 moved away, the longitudinal axis 22, pivot axis 26 and center ray 38 from Fig. 4 are again plotted with dashed lines. Due to the space-saving arrangement of the articulated arm 208 on only one side of the patient 76 (namely the right, which is also the treatment side in Fig. 5), the access to the

patient is enabled with the largest possible free space. The shock head 6 hereby protrudes into a recess 288 (opposite the recess 92) of the recumbent surface 78 in order to be brought optimally close to direct contact on the patient 76.

The x-ray C-arm 4 can pivot on the rotation axis 86 parallel to the orbital plane 40 and perpendicular to the rotation axes 252, 258 and 266. Since the rotation axes 252, 258 and 266 typically run horizontally, the orbital plane 40 stands vertically; the rotation axis 86 for the x-ray C-arm 2 likewise stands vertically. The x-ray C-arm 2 can thus be panned away from the treatment area in the manner of the movement of a door when it is not required. In spite of x-ray C-arm 4 pivoted away, the treatment of the patient 76 with the shock wave head 6 remains spatially precise since its spatial position relative to the SWL system 2 does not thereby vary.

In such a position of the SWL system 2 an inline ultrasound positioning is then possible. The access to the patient 76 is then namely also possible from the back side of the patient table 10 facing towards the machine. The back side of the shock wave head 6 is freely accessible via the articulated arm 208 displaced towards the head end of the patient 76. An ultrasound applicator (not shown) can thus be inserted into a central opening (not shown) in the shock wave head 6 and an ultrasound positioning of the subject to be treated in the patient body can hereby be implemented. The central opening is, perhaps, arranged in the region of the x-ray-transparent zone 96.

Fig. 6 shows an operating situation of the system 2 in which an x-ray radioscopy with the aid of the x-ray C-arm 4 ensues simultaneously with the shock wave treatment of the patient 76 with the aid of the shock wave head 6. The shock wave head 6 is located in the inline position. The x-rays emitted from the x-ray source 34 can penetrate through the x-ray-transparent zone 96 along the center ray 38 of the shock wave head 6. At the same time the shock wave head 6 is positioned on the left patient side corresponding to Fig. 5 (thus in approximately the -40°

position) in order, for example, to treat a kidney stone of the left kidney of the patient (under-table left position as in Fig. 2). Due to the stationary resting isocenter 32, the recumbent surface 79 is displaced relative to Fig. 5 by approximately the distance of the kidney of the patient to be treated from the right patient side. The focus point 70 again coincides with the isocenter 32. The x-ray arrangement 76 is tilted on the longitudinal axis 22 in order to irradiate the patient 76 at an angle. The recess 96 in the recumbent surface 78 in turn offers space for the shock head 6.

From Fig. 6 it is clear that, although the shock head 6 is located on the apparatus-remote side of the patient table 10, this barely protrudes over the apparatus-distal table edge 294 and thus gives the treating doctor sufficient legroom, and therewith furthermore allows the greatest possible patient access. In contrast to the first embodiment, given an articulated arm 208 as a carrier device no further component (outside of the shock wave head 6) is also disruptively present in the head or foot region of the doctor in the over-table position (not shown in Figures).

If patient 76 and recumbent surface 78 are located in a lateral middle position between the positions shown in Fig. 5 and 6, the third significant possibility (not shown in Figures) to treat the patient 76 is present. Given a patient position lowered somewhat relative to Fig. 5 and 6, the shock head 6 can be moved into over-table position in order to treat the patient 76 from above; thus to treat the abdomen side of said patient centrally in the ureter region. The shock wave head 76 would then (for example in Fig. 4) be arranged on the top of the abdomen of the patient 76 between this and the image intensifier 36, such that at the same time an x-ray radioscopy (inline) of the patient 76 can again occur. Here as well no component of the system 2 protrudes beyond the table edge 294 towards the machine-remote side on which the doctor stays. Starting from the position in Fig. 3, this can ensue via tilting of the arm segment 254 on the axis 258 and tilting of the shock head 6 on the axis 266.

Patent claims

1. System (2) for image-supported shock wave treatment, with the following embodiment:

- it comprises an x-ray C-arm (4) that can move orbitally around an isocenter (32), with an x-ray system (34, 36), a shock wave head (6) and a carrier device for the shock wave head (6), which carrier device is arranged to the side of and stationary relative to the x-ray C-arm (4),
- a boom (64) extending towards the x-ray C-arm (4) is connected with its fixed end (67) with the carrier device and bears the shock wave head (6) with its free end (66),
- the boom (64) is directed such that it can move with the aid of the carrier device such that the shock wave head (6) can be arbitrarily positioned in the orbital plane (40) within an angle range of at least 180° above and below a patient table (10) and can be aligned on the isocenter (32).

2. System (2) according to claim 1, in which the boom (64) is forcibly directed in a plane parallel to the orbital plane (40) of the x-ray C-arm (4).

3. System (2) according to claim 1 or 2, in which the carrier device is a C-arm (8) arranged axially offset from and coaxial relative to the x-ray C-arm (4), on which C-arm (8) the boom (64) is borne with its fixed end (67) such that said boom (64) can move orbitally.

4. System (2) according to claim 3, in which the C-arm (8) is borne such that it can move orbitally.

5. System (2) according to claim 1 or 2, in which the carrier device is an articulated arm (208) possessing a plurality of arm segments (250, 254) connected via joints (248, 256, 262), with the free end (260) of which articulated arm (208) the fixed end (67) of the boom (64) is connected.

6. System (2) according to claim 5, in which all joints (248, 256, 262) of the articulated arm (208) exhibit rotation axes (252, 258, 266) running parallel to one another and at a right angle to the orbital plane (40) of the x-ray C-arm (4), wherein the boom is connected such that it can rotate with the free end of the articulated arm (208).

7. System (2) according to any of the preceding claims, in which the shock wave head (6) is crossed by a central region (96) extending along its shock wave axis (68) and that is permeable for x-rays.

8. System (2) according to any of the preceding claims, in which the x-ray C-arm (4) can be angularly panned.

9. System (2) according to any of the preceding claims, in which the carrier device together with the shock wave head (6) can be moved from a treatment position into a park position removed from the patient table (10) or, respectively, a patient (76) borne thereupon.

10. System (2) according to any of the preceding claims, with a patient table (10) crossing the x-ray C-arm (4), which patient table is supported outside of the movement range of x-ray C-arm (4) and carrier device.

Abstract

System for image-assisted shock wave treatment

A system (2) for image-supported shock wave treatment possesses the following embodiment: it comprises an x-ray C-arm (4) that can move orbitally around an isocenter (32), with an x-ray system (34, 36), a shock wave head (6) and a carrier device for the shock wave head (6), which carrier device is arranged to the side of and stationary relative to the x-ray C-arm (4). A boom (64) extending towards the x-ray C-arm (4) is connected with its fixed end (67) with the carrier device and bears the shock wave head (6) with its free end (66). The boom (64) is directed such that it can move with the aid of the carrier device such that the shock wave head (6) can be arbitrarily positioned within an angle range of at least 180°, limited by an above-table position and below-table position, and can be aligned on the isocenter (32).

Fig. 1